

Master thesis for Philosophy in Environmental and Development Economics

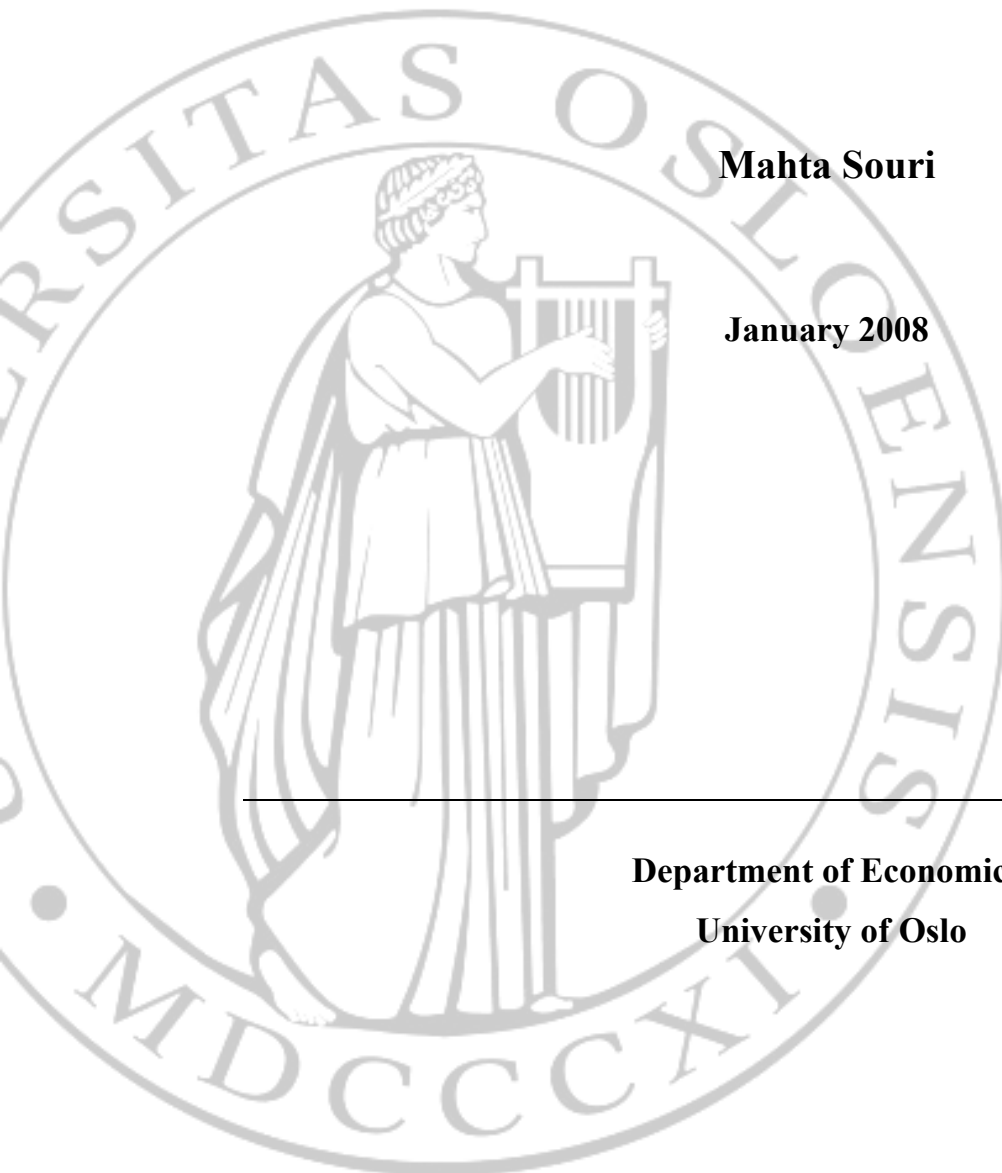
Prevention or Treatment Environmental Innovation

Which one 'Pays to be Green'?

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January 2008

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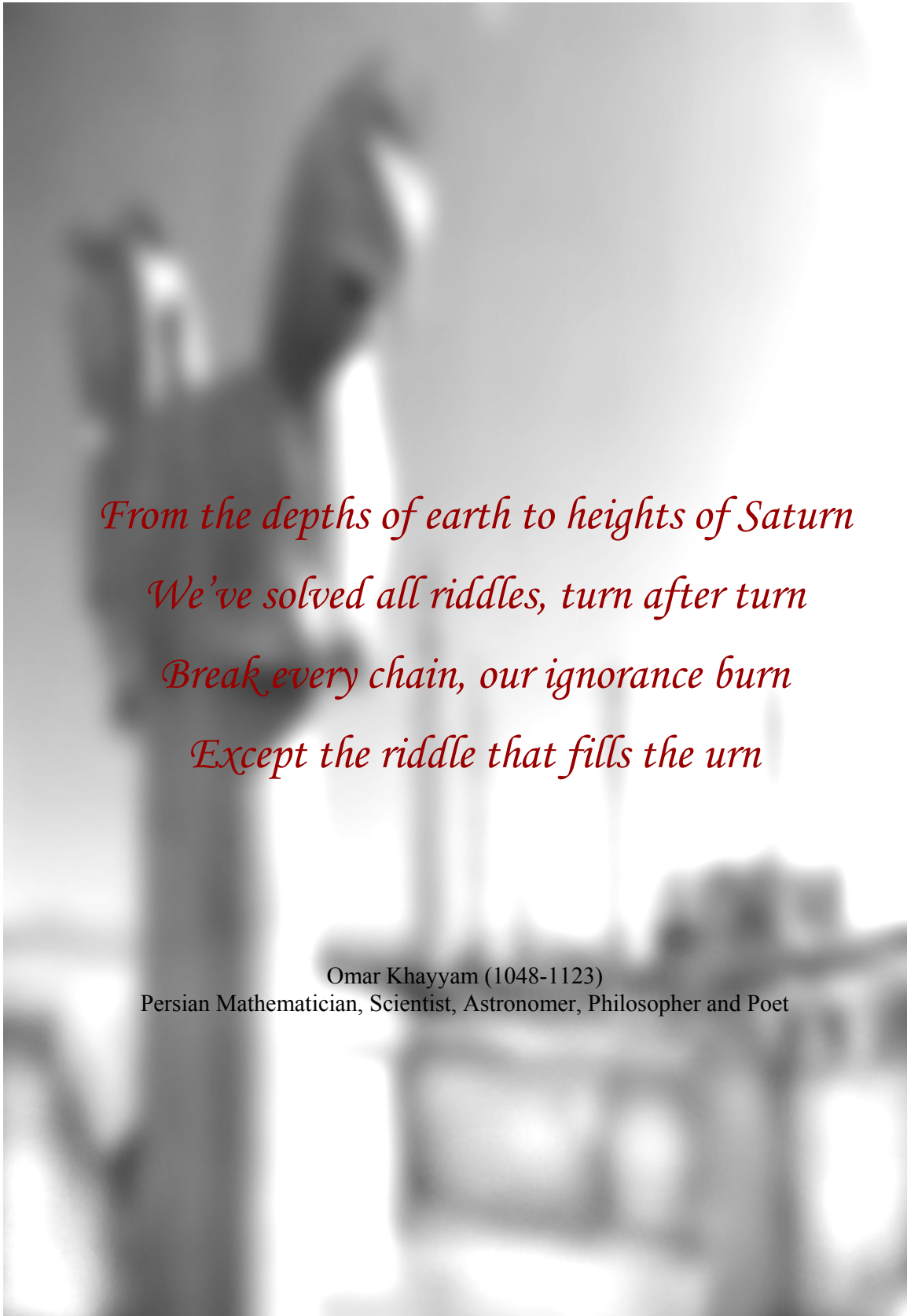
I owe a debt of gratitude to my dear friend Junior Maih and his wife whose emotional support has helped me in the procedure of doing this thesis.

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Above all, thank dear Lord for creating and making me as what I am. May his merciful and supportive grace be upon all and me, forever.

Mahta Souri

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*From the depths of earth to heights of Saturn
We've solved all riddles, turn after turn
Break every chain, our ignorance burn
Except the riddle that fills the urn*

Omar Khayyam (1048-1123)
Persian Mathematician, Scientist, Astronomer, Philosopher and Poet



List of Symbols and Abbreviations

airp.....	Investments in Pollution Prevention in Air domain
airt.....	Investments in Pollution Treatment in Air domain
e_{piz}	Constructed Emission Variable
IPP	Investments in Pollution Prevention
IPT	Investment in Pollution Treatment
SFT	Norwegian Pollution Control Authority
SSB.....	Statistics Norway
TEI.....	Total Environmental Investments
η_{is}	Constructed IPP Variable for Air Domain
φ_{it}	Constructed Total Emission Variable
ω_{ij}	Constructed IPT Variable for Air Domain

Abstract

In recent years, the concern about environmental problems and increasing environmental regulation represents a challenge for profit-maximizing firms. There are suggested approaches toward a so-called win-win situation where both industry and environment can benefit. According to ‘Porter Hypothesis’, environmental regulation can act as a trigger to shoot the target. In the way that, more stringent regulation system will be imposed on a firm, more a firm will be motivated to innovate. The environmental innovation has been divided in two categories: Treatment innovation and Prevention innovation. From the Porter school point of view those firms, which invest in environmental prevention technology, will enjoy innovation offset. Innovation offset can exceed the compliance cost and firms can increase their benefit.

In this thesis, this idea that prevention innovation is more profitable than treatment innovation has been investigated. The analysis is based upon Statistic Norway and Norwegian Pollution Control Authority database, which includes observation from approximately 4323 firms in five industrial sections over four years. In general, the empirical finding of this thesis does not support the idea. On the contrary, there is a strong support for profitability of treatment innovation.

Chapter 1: Introduction

“Financial performance and Environmental performance can go hand in hand. Eco-efficiency is the key to sustainability, in both economic and ecological terms. The key to eco-efficiency is innovation and productivity improvement.”

Alex Krauer, cited in Bernauer, et al.(2006)

In recent years, the concern about environmental problems and increasing environmental regulation represents a challenge for profit-maximizing firms. Many avenues as the options for reducing generation of pollutants have been nominated, such as substitution among inputs, add-on purification, recirculation of residuals, re-localization of activities, and above all change of production technology. Production technology can be improved by reduction in material inputs, changing in types of inputs or reusing the residual. It seems that production technology is the most relevant option with the profit maximization of firm.

Krauer’s statement is one of the countless suggested approaches toward a so-called win-win situation where both industry and environment can benefit. At the first stage, many researches have done attempts to find out basically, if there is any relationship between environmental and financial performance of firm¹. Does a company that strives to attain good environmental performance gain advantages over competitors or it is just an extra cost for the firm? Going to the next step, another group of researches have investigated a more specific question: under regulation, how can firm grab opportunities to get more benefit or reduce its costs regarding environmental performance? The later question has been appeared from the ‘Porter’s Hypothesis’, which simply is “... properly designed environmental standards can trigger innovation that may partially or more than offset the cost of complying with them” (Porter and Van Der Linde, p.98, 1995). Nominating innovation as an important stimulant in firm competitiveness plan is not a new topic in

¹ See, e.g. Cohen et al. 1995, Hamilton 1995, Hart & Ahuja 1996; Klassen & McLaughlin 1996, Telle 2006, etc.

economics literature. Many studies have questioned this relationship under different conditions broadly. In the next chapter, I will look at this relationship more in detail.

Under the assumption of existence of a positive relationship between innovation and competitiveness, does it hold also for environmental innovation? The most pushing factor for green innovation from the Porter's school point of view is the environmental regulation: more stringent regulation system will be imposed on a firm; more a firm will be motivated to innovate. The environmental innovation has been divided in two categories: Treatment innovation and Prevention innovation². The first one refers to an attempt to reduce the existing pollutant/ not-green products (end-of-pipe), while the other appoints the basic solutions to prevent producing pollution/not-green products (integrated). Porter asserts that within properly designed environmental standards the second one generates offsets which can partially/or more than fully covers the cost of complying with regulations. Considering these notions, this thesis has a look toward both innovation types and is an attempt to answer the following question:

‘Does the prevention pollution investment provide more innovation offsets compared to the treatment pollution investment?’

To my best knowledge, the question has not been addressed in literature directly. However, following the seminal work of Porter and Van Der Linde (accounting a link from regulation to promoting innovation which leads to the offsets occurrence), two strands of literature should be reviewed in investigation of *different types of environmental innovations* effects on financial performance of a firm. The relationship between innovation and financial performance of a firm, and the relationship between environmental innovation and environmental regulation are two required sets of studies, which will be explored in the chapter two, the literature review. Third chapter discusses the theoretical approach, which includes social cost and innovation, the definition of prevention and treatment innovation, a very simple economical model and finally

² These two terms will be discussed comprehensively in the body of thesis. Also see Hass, p, 3-5, 2004.

defining proper measures. In chapter four, the empirical approach will be defined, the database, applied variables, econometrics model of hypothesis, and the regression model. In chapter five, I will discuss the regression result and the last but not the least is chapter six which discusses conclusion and opens the new problems for further researches.

Chapter 2: Literature Review

The economic application of a new idea or so-called *innovation* is the performance and growth through improvements in efficiency, productivity, quality, competitive positioning, market share, etc. Typically, innovation adds value; however, it can be considered as a destructive or negative-effect factor in a way that it clears away or changes old custom technologies that imposes cost to the firms. Moreover, it seems the risky and costly features of innovation do not persuade firms to invest in developing their technology eagerly. Nevertheless, due to dynamic character of market structure, innovation is an inevitable phenomenon at present. If a firm intends to remain in the market, it has to go along with new technologies. The firm can either carry out innovation procedure internally or adapt/copy it from the original innovator. In this chapter, I will review some literatures that have studied the relationship between financial performance of a firm and innovation in general (R&D), and- focusing more on the object- those which have studied the relationship between financial performance of a firm and green innovation. I should mention here the question of this thesis is not tracing a relationship between the green innovation and financial performance of a firm generally. Rather, it emphasizes on different green innovations (prevention and treatment) effects on financial performance of a firm. To my knowledge the problem has not been addressed directly in literature; however, reviewing these two strands of literature can shed lit on the theoretical discussion and imply the concept of green innovation relation with financial performance of a firm.

2.1. The Relationship between Innovation and Financial Performance of a Firm

Nås and Leppälahti (1997) in *Innovation, Firm Profitability and Growth*, have explored relationships between innovative activity, profitability, and firm growth in Norwegian industry. They argue that innovation is not costless, since it is followed by an increase in the production cost. Accordingly, the innovator firm is not necessarily more profitable, but likely the more survival and growing. Their second argument states that innovation is

the temporary monopoly power, which the firm gains at the time of offering new product/process to the market. The firms can either increase the price of superior product, which improves returns on sales/assets or hold price down resulting an increase in sales and market shares. “In this case profitability [...] may not improve via innovation, but innovation will improve the growth performance of the firm.” (Nås and Leppälahti, p.9, 1997) Their study is based on a dataset including information from the Norwegian Innovation Survey and accounting data for a panel of industrial firms for the period 1990-1994. They have investigated that two applied measures of profitability (operating profits and return on total assets) are highly correlated, in a way that both measures have shown more or less the same pattern in most of the analysis. They have found innovating firms in Norway have higher rates of growth of sale. However, the research does not support a strong link between innovation and profitability in terms of return on sales or assets. As long as they have not controlled the study with factors like firm size, industry, innovating strategy and innovative inputs, their findings show no major differences between innovator and follower, product and process innovators. Their answer to the question if it pays off to be innovative ‘is not an unambiguous “yes”’. They argue that the answer “depend[s] upon who you are; what business you are in and what you are trying to accomplish.” (Nås and Leppälahti, p.61, 1997)

In a dynamic world, where constantly changes occur in technology, timing is a hard task for a firm. In other words, a firm is faced with the investment time challenge continuously. Mukherji et al. (2006) in their article investigate the importance role of time in making decision for an investment in new technology or upgrading product in IT industry. They argue that choosing the suitable time for applying innovation is a significant factor in firm success. Investing in new product/process is both costly and risky; however, waiting too long can deprive the firm from enjoying the competitiveness in the market. On the other hand, continuous improving, under the assumption of feasibility, is not an optimal tactic where the adoption costs will be significant. They pose “investments in upgrades are best made when the gap between new technology and current technology reaches a *critical* threshold. Among other factors, this threshold is

influenced by technology cost, change management cost and opportunity cost.” (Mukherji et al., p.1692, 2006)

Market pioneering is nominated as a shiny path toward a higher level of competitiveness which is followed by an economically reward for the firm. The linkage between market pioneering and financial performance of a firm has been investigated and much of the studies has yielded inconsistent results. Covin et al. (1999) account the difference in the result is due to ‘*when and how*’ the firm gains pioneering. According to theory and past research, they pose market pioneering is an environment phenomenon. It can be awarded in one environment, while same action of pioneers does not receive reward/ encourage in another environment. Moreover, “firm performance is affected by the fit between a firm’s pioneer/follower status and its competitive tactics.” (Covin et al., p. 175, 1999) They mention two kinds of environment: benign and hostile. In a benign environment, factors associated with product superiority and distribution channel decision are related to firm growth for pioneers and followers. While in a hostile environment, factors associated with product price, product costs, product line breadth, and market breadth are related to firm growth among pioneers and followers. (Covin et al., p. 203, 1999) They argue that these two environments require their own tactic to approach; otherwise being pioneer by itself does not lead to a higher level of economical success.

Kim and Park (2006) in their article cite birthright as another key factor in firm’s success regarding innovation. They have investigated “how a firm's birthright can determine its competitive advantage and its ability to survive an industry shakeout, especially when caused by non-disruptive technological innovations. Birthright is defined as the firm's superior endowment of resources, both tangible and intangible, vis-à-vis competitors', stemming either from its earlier entry into the market or from prior experience in a related market.” (Kim and Park, p, 543, 2006) In their case study, they have investigated Korean mobile telecom industry and their findings support the claim that a firm with greater birthright (reputation or brand) enjoys consolidation in the market regardless of newcomers, which offer innovative products.

Therefore, innovation does not lead directly to a higher profitability level by itself. A firm can improve its economical success by implying innovation, but it has to consider many other factors such as industry, size of its firm, elasticity of market, timing, the tactic between pioneer and follower, and the birthright that are strongly involved.

2.2. Environmental regulation, Green Innovation and Financial Performance

The second strand of literature has looked at how the regulations affect the incentives to innovate and whether these innovations induce profits for the firms or not. Latest in this regard is Lanoie et al. (2007) which provides new insights on the Porter Hypothesis. In their study, the significance of three distinct variants of the Porter Hypothesis defined by Jaffe and Palmer (1997) has been tested using data on the four main elements of the hypothesized causality chain (environmental policy, R&D, environmental performance and commercial performance). These three distinct variants of Porter Hypothesis (quoted from Jaffe and Palmer, 1997) are weak, narrow, and strong version respectively. The ‘weak’ version of hypothesis “is that environmental regulation will stimulate certain kinds of environmental innovations, although there is no claim that the direction or rate of this increased innovation is socially beneficial. The ‘narrow’ version of the hypothesis asserts that flexible environmental policy instruments such as pollution charges or tradable permits give firms greater incentive to innovate than prescriptive regulations such as technology-based standards. Finally the ‘strong’ version posits that properly designed regulation may induce innovation that more than compensate for the cost of compliance.” (Lanoie et al., p. 3, 2007) For testing the significant of all three aforementioned versions, they have used a database collected by the OECD, which includes observation from ca. 4200 facilities in seven countries.³

Their estimation has been conjectured to a strong support for ‘weak’ version, qualified support for ‘narrow’ version and qualified support for ‘strong’ version of the hypothesis. They argue that result for the ‘weak’ version is reassuring the positive relationship between environmental policy and innovation. In fact, it is a logical consequence of

³ See Lanoie, et al., 2007 for more details.

increased policy stringency since “environmental policy changes the relative price of environmental factors of production.” (Lanoie et al., p. 31, 2007) With respect to the ‘narrow’ version, their finding is a support to the claim that flexible performance standards are more inducing for innovation than prescriptive technology-based standards. However, for the market-based instrument this support is no longer valid. Finally, there is ‘some indirect support’ for the ‘strong’ version. While, according to their finding the negative “direct effect of environmental policy stringency on business performance is greater in size than indirect positive effect mediated through R&D, [which] may mean that a large part of the investments necessary to comply with regulation represent additional production costs, such as through investment in end-up-pipe abatement.” (Lanoie et al., p. 32, 2007)

Bernauer et al. (2006) account, “environmental innovations encompass all innovations that have a beneficial effect on the environment regardless of whether this effect was the main objective of innovation.” (Bernauer et al., p.3, 2006) They elaborate their discussion by focusing on explanations of product and process innovations as follows:

“*Organizational innovations* do not reduce environmental impacts directly, but facilitate the implementation of technical (process and product) environmental innovation in companies. *Process innovations* are defined as improvements in production process resulting in reduced environmental impacts, e.g., closed loops for solvents, material recycling, or filters.” (Bernauer et al., p. 3, 2006)

With some adjustment in terms, prevention innovation and treatment innovation are equivalences for organizational innovation and process innovation respectively. Following the applied terms in the thesis, I will continue to appoint the prevention and treatment innovation.

Bernauer et al. argue that to investigate the relationship between environmental policy and innovation, one should distinguish between prevention and treatment innovation which most of the studies have failed to do so. Moreover, market structure and firm internal factors are two fields that have to be considered in this regard. They account the influence

of market concentration on environmental innovation carries ambiguous evidence in literature. Empirical studies have not supported an abundant focus on the environmental improved products followed by customer benefits or providing credible information on their green quality as the determinate of innovation. Hence regarding market structure, ‘competitiveness’ and ‘customer demand’ should be considered as two important determinates. Counting firm internal factors, the authors claim, green capabilities, R&D intensity, and firm size are the most important factors, which their effects on innovation goals, should be focused.

While these two strands of literature have investigated important aspects of objective relationship and shed some lights on the innovation effect on financial performance, they do not address the issue of ‘what type of investments’ a firm should roll in. In other words, this thesis is an attempt to fulfill some of the mentioned suggestions in the studies for the future research, such as taking to account the difference between the treatment and prevention innovation, firm size, the environment of the innovation, etc.

Chapter 3: Theoretical Approach

According to Fagerberg et al., “invention is the first occurrence of an idea for a new product or process, while innovation is the first attempt to carry it out into practice.” (Fagerberg et al. 2005) In turning an invention to innovation, a firm requires investment to transform the new idea to the practical stage; otherwise, it will remain at the concept level. In other words, the investment is the casual factor to make the abstract invention to the concrete innovation. Therefore, investment concept is embodied in the definition of innovation. It is not very plausible that Porter Hypothesis refers to the different inventions rather than innovations. Hence, in this thesis when I discuss firm attempt in different innovation types for pollution protection technologies, simultaneously I mean the different technological investments, which a firm makes.

As I discussed it in the previous chapters, investment or carrying out innovation into practice is both risky and costly. Before focusing on the main problem that investigates the effect of different types of investments (prevention and treatment) on financial performance of a firm, one should examine the necessity of innovation. In this chapter, I briefly discuss the concept of social cost and its components, individual cost and unwanted cost, and explain how innovation can be a remedy to minimize the unwanted cost. The prevention and treatment innovation definitions will come afterward, then I define a very simple economical model, which represent the relationship between financial performance and investments, controlling by environmental performance. Due to the significant role of environmental performance, which will be explain further, the chapter goes on by discussing the relationship between financial and environmental performance of a firm. Finally, defining the proper measures for the aforementioned variables concludes the chapter.

3.1. Social Cost and Innovation

It is logical and acceptable that a firm target is profit maximizing, avoiding any extra cost and environmental performance, or *being green*, in deed has cost at least in the short run. However, there are always two sides to every story. If the firm wants to skip this cost, it will be imposed on someone else, or in a better word, the society. In general those firms that their productions come up with producing emission, impose part of *social cost*⁴ to the society. Let us see what social cost is. Consider an example: The private cost to a motorist of driving between Oslo and Bergen is the cost of petrol and oil and wear and the tear on his car. However, the other people have to put up with the externalities of the journey, for instance the noise, smell, pollution and traffic congestion the motorist helps to cause along his way. If I added on to private cost an amount of money to compensate for the inconvenience caused, the over all figure will be the social cost of journey.

$$\begin{array}{rcl} \text{Private cost} & + \text{Externalities} & = \text{Social cost} \\ (\text{Cost to individual}) & + (\text{Unwanted Cost}) & = (\text{Cost to everyone}) \end{array}$$

In my discussion, I am interested in the second part of this sum, unwanted cost. The cost of emission may be different from case to case. It can be a reduction in an individual's utility, destruction of natural resources, and depletion of species of an animal or in a crucial case putting in danger the health of human beings. In most of the cases, let us say in all, the exact measuring of social cost is not possible. For solving this, we can just have an estimation of its measures. The purpose of environmental regulation is to correct for negative externalities that increase the social cost.

In neo-classical economics, environmental regulation is viewed as “a means to force firms to internalize external costs they would otherwise impose on society.” (Bernauer et al., p. 4, 2006) A firm that produces emission or has a weak environment performance imposes cost to the society and it is not green. If the firm wants to be green, it should

⁴ I am guided here by Pigou who is responsible for the distinction between private and social marginal products and costs. He originated the idea that governments can, via a mixture of taxes and subsidies, correct such market failures — or internalize the externalities.
(Wikipedia http://en.wikipedia.org/wiki/Arthur_Cecil_Pigou, Accessed, 23 Sep, 2007)

reduce its emission until bottom line so that in the ideal form the emission will be zero⁵. Nevertheless, until providing that utopian condition, one should endure the unwanted cost. With the lack of ‘firm greenness’, all the costs will be transferred to the society (individuals, planets, animals, nature, etc.). That is what was happening in most of the industrial sectors before the environmental regulation contract will be signed. The cost can be divided to each side of the parties, producer, and consumer. For the consumer, it can be either paying higher price for the firm’s good products or tolerating the consequence of legally emitted pollution. For the producer, its share is the payment for economic incentives such as pollution fees, marketable permits, and liability. In our discussion, the focus is on those kinds of firms, which follow the imposed regulation and they endure some costs for being green.

The point of this thesis is neither offering optimal solution for the minimum cost considering both sides, nor chasing a robust positive relationship between environmental and financial performance of a firm as it has been already studied vastly. Rather, this thesis investigates a suggested solution to minimize ‘firm share’ from the unwanted cost.

Porter accounts that the firm’s share from this unwanted cost is more than what it should be. From the ‘Porter School’ point of view, the relationship between the financial and environmental performance of a firm holds a negative one as far as firm’s optimization framework is considered static and no opportunity for innovations will be assumed. While in reality, a firm is surrounded by “dynamic competition which is characterized by changing technological opportunities.” (Porter et al., p.99, 1995) It can be put in another form. If we assume that the unwanted cost is imposed on all firms, then the question will be *how a firm can have superior productivity in compare to its rivals*. Porter suggests that under regulation, firm will be smarter about the approaches toward emission reduction and eliminating the costly process/ product. In this way, there is decrease in its both cost and emission.

⁵It may raise this claim that from economical point of view, the zero level is not an ideal situation; though, in some situations having a level of emission is more idealistic. But, the study is pointing out to the technical aspect rather than its economical one.

Narrowing down the discussion, the benefit-chain of firm can be presented as follows:
When a stringent regulation will be imposed on a firm, it acts as a spur to innovation and due to the character of market; there are countless avenues for technological improvements. These improvements coupled by innovation offsets, increase the financial success of a firm or decrease its share from the unwanted cost.

3.2. Prevention and Treatment Innovations

Porter et al. argue, “Companies must start to recognize the environment as a competitive opportunity- not as an annoying cost or a postponable threat.” (Porter et al., p.114, 1995) It is time for companies to get benefit of the regulation rather than finding ways to avoid it or fight for more pollution quota or other illogical solutions which may lax their regulation, but nothing positive can be achieved in a long term.

Mainly Porter et al. suggest a well-crafted environmental regulation can ‘act as a spur to innovation’ that situates the firm in a win-win opportunity, and under the regulation “*Innovation offset*” is the key factor of persuasion for the firms. They discuss, “Competitiveness at the industry level arises from superior productivity, either in terms of lower costs than rivals or the ability to offer products with superior value that justifies a premium price. [...] internationally competitive companies are not those with the cheapest inputs or the large scale, but those with the capacity to improve and innovate continually.” (Porter et al., p. 97-98, 1995) In their article, Porter et al. pose the competitive advantages enjoy neither from static efficiency, nor from optimizing within the fixed constraints. Rather the competitive advantages gain imputes from the capacity for innovation and improvement that shifts the constraint. They continue that within properly designed environmental standards the stimulated innovation can partially/or more than fully offset the cost of complying with them. Hence innovation is a shiny path toward the minimizing the environmental protection cost which a firm has to deal with.

Porter et al. expand their discussion and in the first from six serving purposes of a properly crafted environmental regulation, they define two kinds of innovations, which under regulation firms try to invest in. One form of innovation “reduces the cost of

compliance with pollution control, but changes nothing else,” where the other one “addresses environmental impact while simultaneously improving the affected product itself and/or related processes.” (Porter et al., p. 101, 1995) In this thesis, guided by definitions from Statistic Norway (SSB) I appoint these two innovations treatment innovation and prevention innovation respectively. (Hass, p. 3-5, 2004) Following is the definition of these two kinds of investments by SSB.

Investments in pollution treatment are also called investments in “end-of-pipe equipment” or known as “process external” equipment. These are defined as “capital expenditures for methods, technologies, processes, or equipment designed to collect and remove pollution and pollutants (e.g. air emissions, effluents or solid waste) from the environment after their creation, prevent the spread of and measure the level of the pollution, and treat and dispose of pollutants generated by the operating activity of the company. Pollution treatment includes investments in equipment (e.g. filters or separate cleaning steps) which compose or extract pollutants within the production line, when the removal of this equipment would not affect the functioning of the production line.” (Hass, p. 4, 2004)

Investments in pollution prevention are also called investments in “integrated technologies” or known as process internal equipment. These are described as “capital expenditures for new or adaptation of existing methods, technologies, processes, equipments (or parts thereof) designed to reduce or eliminate the creation of pollution, or change the composition of pollutants (e.g. toxicity), at the source, thereby reducing the environmental impacts associated with the release of pollutants and/or with polluting activities”. (Hass, p. 4, 2004)

Porter et al. pose that the second form of the innovations (prevention innovation) is the central for their claim that ‘environmental regulations increase industrial competitiveness’ followed by a higher level of firm’s success. Briefly, they argue those firms, which invest in prevention technologies, get more benefit from the market. Getting more benefit can occur when the firm is pioneered in the technology, and can sell the new technology or its patent to the other firms. Introducing new prevention technologies can

avoid the occurrence of particular episodes of pollution. Some large companies have almost gone bankrupt over particular episodes; moreover, in a case of an accident in may lead to a national catastrophe such as Union Carbide in the case of Bhopal⁶, India in 1984. Marketing will be more effective when one can market “basic-green” labeled products and process⁷. This thesis is an attempt to compare the profit of those firms, which have invested in prevention technologies and those in treatment technologies.

Here I would like to expand the concept of pioneering in innovation which has been addressed in literature review briefly. A firm can enjoy the new technology in two ways: One way is investing in an innovation and carry it out to practice; in this case, the firm is pioneer/innovator. Although the investment imposes a relatively high cost to the firm, the innovator firm can enjoy selling the patent or keep the technology protected and get prosperity from market due to its privileged new product/ process. Smart innovator firm is aware of rapid stream of new-come innovations, so the firm infers that this pioneering prerogative does not last too long. Hence, the innovator should export the technology to the other firms in the market, but not the knowledge/ information support and make a benefit by providing support services for the non-innovator/followers firms.

The other way for enjoying an innovation is to adopt/copy it from the innovator firm. In this case, the non-innovator/follower firm does not require enduring the investment cost and can save its arrows for the best hunting. In other words, the follower firm is deprived from the pioneer firm’s advantages (rights, patent, and so on.); however, it will get the completed, qualified, and standard product without spending its both time and relatively high fiscal resource on that. Many studies have investigated the profitability of these two

⁶ The chemical accident was caused by the introduction of water into methyl isocyanides holding tank E610, due to slip-blind water isolation plates being excluded from an adjacent tank's maintenance procedure. The resulting reaction generated a major increase in the temperature of liquid inside the tank (to over 200°C). The MIC (Methyl isocyanides) then gave off a large volume of toxic gas, forcing the emergency release of pressure. A Union Carbide subsidiary pesticide plant released 40 tones of MIC gas, immediately killing nearly 3,000 people and ultimately causing at least 15,000 to 22,000 total deaths. Bhopal is frequently cited as the world's worst industrial disaster.

(Wikipedia, "http://en.wikipedia.org/wiki/Bhopal_disaster", Accessed, 17 July, 2007)

⁷ Not being green, make some firms unable to gain access to certain markets when the environmental standards are low, e.g. certification mechanism (such as ISO 14000). Many large multinationals companies require ISO 14000 certification of subcontractors, for these to deliver inputs to these firms. One example is pulp and paper industry in Germany.

kinds of firms (innovator and non-innovator). For example, Nås and Leppälahti (1997) in their study have found no significant differences in profitability between innovators and non-innovators for Norwegian industry as a whole. However, when they control for some factors such as firm size, and industry section they have different results. (See Nås and Leppälahti, p. 63-65, 1997) Similar to what I have discussed regarding persuading firm to be green, I emphasize that this thesis is not an attempt to persuading firm to innovate. Rather, its object is to *compare the profitability of those pioneer/ innovator firms, which invest in different types of innovations: prevention and treatment.*

As discussed earlier, the innovation offsets resulting from prevention innovation, Porter et al. suggest, can exceed the cost of compliance. Investments in prevention technology can offer two kinds of offsets: Product offsets and Process offsets. As the authors account these two offsets are related, so that achieving one of them can be followed by the realization of the other. These two offsets occur when, in addition to reducing the emission, the products enjoy a “better-performing/higher-quality, more safety, lower product costs,” etc. and the process enjoys “higher resource productivity such as better utilization of by-products, lower energy consumption, material saving”, etc. (Porter et al., p.101, 1995) In this thesis, I consider these two offset together as the total offsets of prevention innovation investments and comparing them with the offsets of treatment innovation is the object problem.

3.3. The Economic model

In this section, I want to investigate the relationship between the financial performance of a firm and different types of investment in innovation. Here I simply present a model:

$$\pi = f(IPP, IPT, Z)$$

Where π , IPP , and IPT are profit of firm, Investment in Pollution Prevention and Investment in Pollution Treatment technology respectively. Z is the vector of control variables.

It is assumed that profit is a function of innovations. In this model, there is no time-subscript due to the different time relationship between the components of this model. In this section, I discuss the model without time-index interfering and in section 3.4.4. (Time lag), I explore time relationship in detail.

The purpose of this thesis is to find out whether there is any relationship between the investments and profit. In case of existing a positive relationship between them, which of them (*IPP* or *IPT*) has a higher share in profit increase. Z is the vector of control variables, here environmental performance. It is clear the goal of these kinds of investments is to reduce the emission or improving the environmental performances while increasing profit/ reducing cost. Identifying the relationship between the aforementioned investments and profit of a firm requires analysis of the relationship between the environmental performances and financial performances of a firm.

I argue that omitting the improvement in the environmental performances of a firm may lead the study to a non-valid result. Not considering the environmental progress operations, investment in pollution protection may cause an increase in the profit of a firm; however, this change in profit can appear due to many other different factors, which *greenness* of the firm may have no role in. For example, an increase in price of outputs in a period, while having investment in environmental performance, may lead to a higher rate in profit. Although an increase in profit will be achieved, it is not owed to a better environmentally performance, and possibly no change has been occurred in the level of pollution and the firm acts as before.

Avoiding the problem of omitting relevant factors, I strongly suggest that in studying the relationship between the pollution protection investments and the financial performance of a firm, the environmental performance of a firm should be considered. If the investments will not come up to a reduction in the level of pollution or does not provide an insight toward the approach of doing that, the investments is a cost which firm has been endured in vain.

3.4. Defining proper measures

A proper measure of success for both financial and environmental performance of a firm will not be achieved easily. Estimating innovation does not seem a very easy task to do. Presenting a well-defined measure theoretically which covers all aspects, does not mean the measure will be supported empirically. Shortage of data, inaccuracy in firms report regarding their performances, appearing new phases in industry and many other factors can be called as excuses for inability to come up with an acceptable measure. Yet the following sections offer estimation to measure the innovation concept in addition to a list of both performances measure, which have been applied in previous researches: Financial performance and Environmental performance.

3.4.1. Innovation Measure

How best to measure a new idea/procedure has been a crucial task for the business section over the years. Creating an accepted metric system for measuring creativity in order to compare its benefit with its cost is still an inconclusive concept in the literature. These are the problems, which have been counted for measuring innovation, but they actually pointed out to invention not innovation. Although these two words are used interchangeably and connected, as I discussed earlier, they are not the same. Innovation is the concrete extension of invention. Apparently measuring an abstract concept (invention) is a very hard job to accomplish, but the goal is to measure the innovation that is 'the invested invention'. Hence, in this thesis 'investment' is the measure of innovation.

One may claim that the better way to evaluate the innovation is to consider its both sides: cost and benefits. I argue that considering innovation cost and benefit is measuring its profitability not itself. Although investment is the measure of innovation, the object of this thesis is to measure the profitability of different kinds of innovation. In doing so, investment can be considered as cost in one hand and the advantages which follow the occurrence of innovation (patent, higher market share, etc.) can be considered as benefits in the other hand. The net sum of these two sets represents the profitability of the

innovation. Theoretically this thesis has addressed the increase in the profit which is caused by innovation. However, in the empirical part due to the data shortage, the change in profit has been considered generally by all factors, which is a noticeable shortcoming indeed.

3.4.2. Financial Measures

Financial performance measures all efforts to optimize monetary and fiscal productivity of a firm. It can be measured by operating surplus of the firm or the rate of returns. Here is a list of some of the most common used variables as a measure of financial performance of a firm.

- *Total Return:* It is defined as the sum of the increasing in market value and the value of any dividends over a period. According to the traditional financial theory, the firm stock price represents the economic value of a public corporation. Thus, the growth in stock price indicates the growth in that value over any period. However, one must include the value of any dividends made to shareholders over the period investigated. (Cochran & Wood, p. 45, 1984) Because dividends represent a type of economic return and they tend to decrease the stock price, all else being equal.
- *Return on Investment (ROI):* A common measure relates the income (before extraordinary items) of a firm to the value of capital invested to produce the income.

$$ROI = \text{Net Income} / \text{Invested Capital}$$
- *Return on Equity (ROE):* It is a common financial measure that relates the income (before extraordinary items) over a period to the average total market value of the firm that generates those earnings. For the purpose of ROE, market value is common equity determined by multiplying the average number of common shares outstanding times their average value.

$$ROE = \text{Net Income} / \text{Common Equity}$$
- *Return on asset (ROA):* It is another common financial measure that relates the income to the asset based used to generate those earnings.

$ROA = \text{Net Income} / \text{Average Total Assets}$

- *Sale Growth*: It represents the rate of change (in percent) for firm sales (or revenues) over a period.
- *Net Income (NI) Growth*: It defines a rate of change (in percent) for firm net income over a period.

All mentioned measures above are the most common used in empirical work, in addition to other measures such as Tobin's q (Konar & Ahuja, 1996), earning per share growth forecasts (Corderio & Sarkis, 1997), etc.

3.4.3. Environmental Measure

Environmental performance measures how successful a firm is in reducing and minimizing its impact on the environment, and encompasses all efforts to minimize the negative environmental impact of the firm's products throughout their life cycle. Several criteria have been suggested as relevant measures for environmental performance such as reductions in emission data, pollution control, direct compliance expenditure, or environmental ranking.

- *Emission Reduction*: The percentage change of firm's emission efficiency index over several years. The emission efficiency index is the ratio of reported emission in pounds to the company's revenues in thousand of dollars. (Applied by Hart and Ahjua, 1996)
- *TRI88*: The aggregate pounds of toxic chemical emitted per dollar revenue of the firm. (Applied by Konar and Cohen, 2001)
- *LAW89*: The number of environmental lawsuits pending against the firm in 1989. (Applied by Konar and Cohen, 2001)
- *TRI Discharges*: The toxic release inventory discharges.

As we can see, a very clear difference between the financial measures and environmental measures is that those defined financial measures can be applied in any region and any time, but for environmental performance any study has its own measures and each of

them has chosen a built-up variable which cannot be applied for the others. An ideal form of a measure should include:

- All kinds of emission regardless of emission nature.
- All victim regions: air, water, etc or even out of the earth.
- Both stock and flow emission.
- The sensitivity about the edge of toxic level of emission.
- All parts of time.

Making such measures seems impossible, but with some adjustment in, maybe a good one can be achieved. This thesis suggests the changes in emission as a measure for environmental performance, applied in the study by Hart and Ahjua. Although, it does not provide the amenity value of an ideal measure completely, it covers many aspects of a good measure.

In some of the researches, market value, role of management, and firm size are considered as very important factors. Regarding the difference in feature of activities of firms, market value may varies from case to case and cannot be considered as an over general factor for all the firms. But, I would like to explore the two other concepts, which seem to have significant roles in the firm behavior studies, namely management and firm size.

Role of management

Not inserting the 'role of management' as an effective factor in performance of a firm has been claimed as a considerable shortcoming in many empirical studies. Obviously, the quality of managerial decisions can appoint firm's level of success. One of the most important managerial decisions is how to allocate fiscal sources appropriately to the different parts of the structure of a firm. Focusing on the discussion, the role of a successful management can be manifest in improving "environmental performance in the most economical manner." (Schaltegger and Synnestvedt, p. 5, 2001) To judge which of the various investments (prevention and treatment) will reward company more economically requires management considers various factors. Hence, the choice of environmental investment in prevention or treatment technology is an indicator for the

profound insight of the management. In this way, the role of management has been embodied in the study by applying these two kinds of investments.

Firm size

In some of the researches, the firm size has been considered as an important control variable. Disregarding firm size factor, the studies diverge from the real estimations regarding different performances of firm. (financial, environmental, etc.) In other words, considering firm size, a *bigger* firm can have more quotas for pollution in compare to a *smaller* one or comparing financial performance of a *bigger* firm with a *smaller* one is not a valid study. At the first look, it sounds reasonable; nevertheless, what is the firm size? What is the criterion for being small or big? There is no exact definition of firm size, whether it means the number of its employment or heavy machinery and equipments or the range of its activity and production or even its reputation in the market. Most of the studies have control firm size by the number of employees. However, in some researches the bottom line of a big firm is hundred fifty employees, while in some others studies having at least two hundred employees set the firm in big-firms category.⁸ As Tirole (Tirole, 1988) states, according to the various definitions of the firm⁹, there are various factors which represent the firm size. As we can see, there is no accurate definition for the firm size. But, what is the account for the importance of firm size? The reason is that a firm behavior will be investigated/ compared with the other firms at the same level/group. For example the different performances of a firm like Norsk Skog should not be compared with a domestic firm involved in pulp and paper industry in Norway.

Here I can suggest a solution to skip the firm size problem: *deflating*. By deflating I mean any required variable for the firm performance will be deflated by a relevant factor. Considering firm financial performance measure, I suggest the ratio of profit over capital. Obviously, all efforts of a firm should lead to maximizing its profit. These efforts or inputs can be listed as a successful management, hiring more employees, importing new

⁸ Näs and Leppälahti (1997) control firm size for fifty employees, while the threshold of a big firm has been considered two hundred employees in Rehfeld et al.(2006)

⁹ It focuses on oligopoly firm definition.

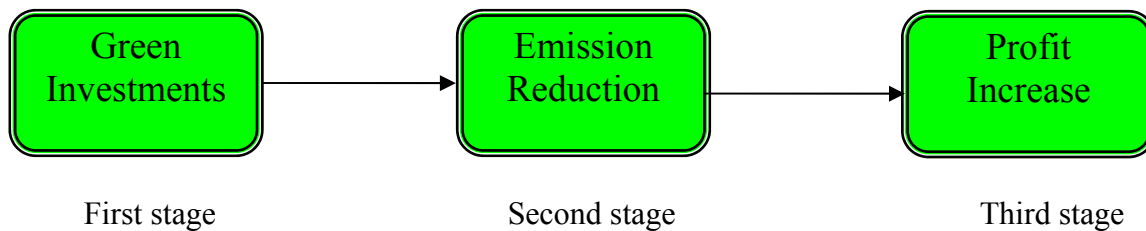
technologies or heavy machinery, etc. I argue that when there is an increase in firm's inputs (makes itself larger/bigger), it is expected an increase in the outputs. According to the definition, productivity is the amount of output (in terms of goods produced or services rendered) per unit of input achieved by a firm. The effect of productivity shows itself in the profit of a firm. The problem of firm size for financial variables can be amended if we consider a ratio of the profit proportional to the capital of a firm. In this way, the firm is conditional to its own profit and capital regardless the amount of profit or capital since it is their ratio. Either it is a large or small firm will not influence the study very strongly. The same argument can be stated for the other performances of a firm. In the next chapter, I will discuss my suggested normalizing factors for the other variables. (investments and environmental performance) One benefit of following deflating solution is to have more observation in samples. Classifying the firms will reduce the sample size and in some cases due to the lack of data, the population will be too small to investigate. With deflating, the sample includes all the firms which are conditional to their own factors.

3.4.4. Time Lag

The features of a proper measure for the variables have been discussed. Now the question is that 'how their time- relationship should be.' It is obvious there is a time difference between investment and getting result in the profit. Investment has an initial outlay and then there is a benefit stream over many years later. Apparently, if there will be an investment in technology (here environmental) for present period/year¹⁰, the result will not come up until the next year or very probably several years later. If a firm invests in year one, the effect of this investment requires at least one year to show up in environmental performance. Considering environmental protection investment, there is even a time difference between treatment investment and prevention investment. Investment in treatment technology may show result quicker than investment in prevention technology or vice versa. Moreover, the firm cannot enjoy financially sooner

¹⁰ The investment effect can be traced in different time intervals. Since a firm financial balance sheet is annually, I consider year as the index of period.

than improving its environmental performance. Looking at the relationship between variables, hence it faces a lag for more than two years. In other words, if a firm make an investment at time 't', the changes in emission will be seen at time 't+1' or 't+2', etc. The firm may get benefit from that investment financially at time 't+1' (not very likely) or 't+2' and so on. As a result, financial performance is the most lagged variable among all of them.



I argue that in doing such researches one should notice to the role of time lagging which influences the relationship between the aforementioned variables. A correlation table can serve the object. The table can present the correlation between investments, financial performance, and reduction of emission over various years. The highest correlated years, can be considered as the related- lagged years. Although it seems an efficient suggestion to find out the time-crossing relationship between variables, it may face difficulties in practice. For representing a plausible time relationship, there should be enough data over many years, which seems not very promising at present regarding various environmental investment data sets.

Chapter 4: Empirical Approach

Considering empirical attempts, we face diversity in results, which can be explained by many factors such as different data sets used, different constructed variables, and different samples. In the same way, differing in regulatory regime in a country, the industries analyzed, the considered victim environment domain (air, water, solid waste, odor/ noise, others), the way how to theorized the framework to evaluate this relationship, and many other factors can divert the results from a convergence.

Lanoie et al. criticize Porter Hypothesis and assert, “[...] the evidence initially provided in its support is based on small number of company case studies, in which firms were able to reduce both their pollution emissions and their pollution costs. As such, it can hardly be generalized to the entire population of firms.” (Lanoie et al., p. 2, 2007) Apparently, it is a noticeable comment. However, running empirical researches can lead to a path that can come up with a generalized conclusion, which covers somehow the entire population of firms. Any further empirical attempt can remedy at least one shortcoming or look at the problem from a different angel so that shed more lit on the problem. The present thesis intends to do its duty in this regard and investigate *the effect of different kinds of environmental innovations (investments) on financial performance of a firm* empirically. Once again, I remind that this thesis deals with those firms that are highly regulated and have an attempt to reduce their compliance cost by means of investment in green innovation.

In doing so, this chapter includes four sections. The first section is devoted to database description. The advantages and shortcomings of measures that the previous researches have applied in their studies have been discussed in previous chapter. However, the present thesis follows somehow the same rule (apply the unsatisfactory available data) and defines the applied variables in the second section. In section three, I describe how the model is structured based on accessible data. Although, by amending two suggested

important shortcomings of most previous studies, namely firm size and quality of management variable, the study seems to keep a short distance from the circle of shortcomings. Finally, a regression model will be presented which upon the model is estimated.

4.1. Database

The applied sample is the Norwegian industrial section where if a firm in industrial section is granted an emission permit, Norwegian Pollution Control Authority (SFT) puts the plant in one of four so-called risk classes. Being at class one, nominated the firm as a potentially highly environmentally dangerous, while the potentially least environmentally dangerous plant is placed in risk class four. Glombek and Raknerud (1997) argue that firms in risk classes one and two are considered highly regulated. For my purpose, the firms in classes one and two according to SFT classification have been considered.

All the data used are from SSB (Statistics Norway) and SFT (Norwegian Pollution Control Authority). I have constructed panels of annual firm level data for 4323 firms in five selected industries: manufacture of pulp, paper, and paper products, manufacture of coke, refined petroleum products and nuclear fuel, manufacture of chemical and chemical products, manufacture of other non-metallic mineral products, manufacture of basic metals. The observation unit is the firm: “A firm is defined as smallest legal unit comprising all economics activities engaged in by one and the same owner and corresponds in general to the concept of a company. [...] A firm may consist of one or more establishments (plants). The establishment is the geographically local unit doing economic activities within an industry class.” (Cappelen et al., p. 39, 2007)

The required datasets for this study are as follows:

- profit index (profit and capital dataset at firm¹¹ level, provided by SSB)
- Air Emission dataset(SO₂, NO_x, and CO₂, provided by SFT at firm level)

¹¹ Foretak is the Norwegian equivalence term for firm.

- Investment in Pollution Prevention (integrated) and Investment in Pollution Treatment technology (end-up-pipe) both for climate, since the available emission data covers only air (provided by SSB at plant level)

For constructing variables, the following data were provided: Organization number of each firm (registration number), Organization number of each plants,¹² Year, Profit (operation result¹³), Capital (building and construction plus other long term properties in current price¹⁴), Production cost, Total investment in treatment technology, Total investment in prevention technology, Investment in air protection (treatment), Investment in air protection (prevention), Annual amount of emitted CO₂, SO₂, and NO_x for each firm respectively, and finally Nace code which represents the industrial section a firm is active in.

Since the profit, capital, and air emission datasets were constructed on firm level, I aggregate the plants investments datasets to the firm level. In other words, having the same organization number, put the plants in one firm and aggregate their data under the firm. Organization number was the link between these three datasets. Although different sources for datasets (SSB and SFT) has caused difficulties in merging them according to the organization number, the problem was solved by getting help from 'Register Authority and Source of Information.'¹⁵ In doing so, those firms that lacked the organization number in datasets were searched according to their name to get the related organization number.

The data for investment in treatment technology is available from 2000, while the investment in prevention technology is gathered from 2002. Hence, the observation period is the 4-years period 2002-2005. Initially all firms in an industry that were operating during this period were included in the sample. A firm was excluded from the sample if:

¹² Bedrifts nummer in Norwegian.

¹³ Driftsresultat in Norwegian.

¹⁴ (Bygniger og anlegg + andre varige driftsmidler) i løpende pris in Norwegian.

¹⁵ www.brreg.no Accessed: 30 Dec. 2007.

- (i) the firm has not invested on environmental protection in any year/ the related data is missing
- (ii) the firm emits a pollutant rather than CO₂, NO_x, and SO₂ due to the lack of data
- (iii) the firm is not ranked among 1 or 2 SFT's ranking¹⁶

4.2. Applied Variables

In the following section, I define and present the applied variables in this thesis. Although many other variables can be applied for investigating the effect of different investments on financial performance of a firm, the followings are the suggested variables based on available data.

4.2.1. Applied Financial (Dependent) Variable

The suggested variable is the ratio of profit over capital. As I discussed it earlier, in this way the problem of firm size will be discolored up to a great deal. The documentation of the capital database is carried out by Statistics Norway, which consists of data for tangible fixed assets for the manufacturing joint-stock companies.¹⁷

The database contains computed values of tangible assets in current prices. The data for profit is the financial surplus/deficit which shows if the total revenues exceed the total expenditure in a firm.¹⁸

$$4.1 \quad Y_{it} = \text{Profit}_{it} / \text{Capital}_{it}$$

i denotes the number of firm and t is the time index.

¹⁶According to SFT ranking A firm is categorized into one of the four classes:

1= the potential most environmental dangerous firm, 4= Least environmental dangerous firm , 2 and 3 are intermediate firms.

¹⁷For more detail, refer to Documentation of the Capital database, A database with data for tangible fixed assets and other economic data at the firm level, Raknerud, Rønningen, and Skjerpen, 2004.

¹⁸SSB, http://www.ssb.no/vis/english/subjects/12/01/20/kommregnfy_en/main.html. Accessed, 02 Oct, 2007.

4.2.2. *Applied Investment (explanatory) Variables*

The explanatory variables are the different types of firm's investments regarding their environmental performances. The methodology of collecting data for different green investments is through a survey for manufacturing industries by Statistic Norway. The questionnaire consists of two parts: Current cost (driftsutgifter) and Investments (investeringer) regarding firm environmental protection activity.¹⁹ The second part is divided in two sections: process external investments and process internal investments.²⁰ Each section gives an explanation regarding the definition of aforementioned investment.

Figure 1 Example of question for investment in treatment (end-up-pipe) technologies

English Translation:

Has the firm made an investment in external process [treatment technology] plan or instrument in 2002?

Figure 2 Example of question for investment in prevention (integrated) technologies

English Translation:

Has the firm made an investment in integrated [prevention] technology in 2002?

¹⁹ The questionnaire is given in appendix A.

²⁰ 'Prosesseksterne investering' and 'Prosessinterne investering' terms in Norwegian respectively.

In addition, in each section the firm is asked about the invested domain (receptor) specifically. The gathered data is according to the firms' reports and as Hass and Smith pose, "The concept of environmental protection expenditure is far from being established as a standard accounting concept by financial accounting bodies. Norwegian enterprise and industry organizations are using very different approaches and definitions for their own use and for reporting in their annual reports and their environmental reports." (Hass and Smith, p. 5, 2002) Many problems can put a question to the accuracy of data, such as:

- the ambiguity in the distinctive line between the investment in equipments and investment in better off progressing in environmental performance
- the lack of clear concept for each of the investments from firm's point of view
- variety of the definition of equipment for environmental protection over time

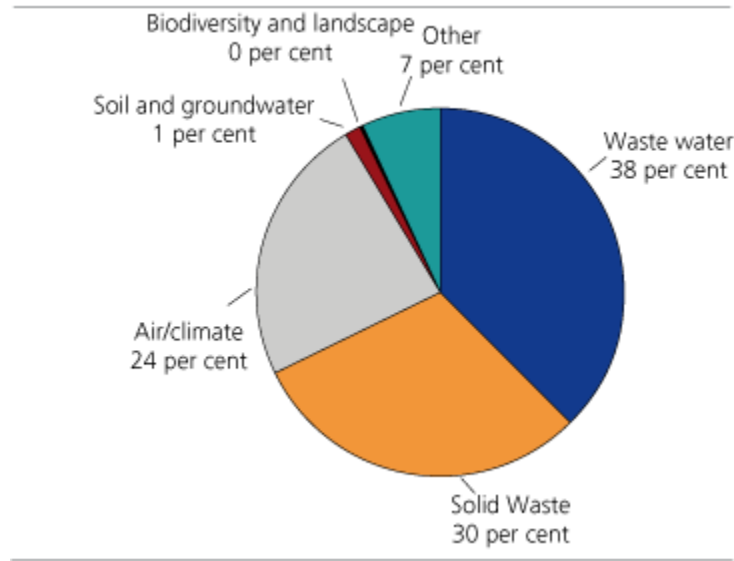
These and many other problems can mark the data as unsatisfactory one. However, the measures have been done more structurally and until this year (2007), the data for four years (2002-2005) is provided. Due to the lack of data regarding the other kinds of emission, this thesis is devoted its investigation just to the air receptor/ domain in Norway.

Air is the ocean we breathe and supplies us with oxygen. There are several main types of pollution and well-known effect of pollution, which are commonly discussed. These include smog, acid rain, the greenhouse effect, and ozone depletion. "Emissions of carbon dioxide and other greenhouse gases contribute to enhancement of the greenhouse effect created by man. As a first step to limiting the greenhouse effect, Norway has, via the Kyoto Protocol, undertaken obligations for the development of greenhouse gas emissions."²¹ According to SSB, there is a reduction in emissions of nitrogen oxides (NOx) in previous years. However, the emission target is still some way off. Moreover, a considerable part of the environmental protection expenditure in Norway has been amounted to air/climate. Figure three, shows that near 24 percent of environmental protection expenditure has been amounted to the air/climate.²²

²¹ Statistic Norway http://www.ssb.no/klima_en Accessed: 20 Jan, 2008.

²² Statistic Norway http://www.ssb.no/english/subjects/01/06/20/miljokostind_en/main.html Accessed: 20 Jan, 2008.

Figure 3 Environmental Protection Expenditure by domain, percent



Hence, for constructing variables for different investments, this thesis has applied different kinds of investments for air/climate domain. As I explained earlier under the firm size section, the suggested normalizing factor here is the total investment in environment. Each firm's different investment is normalized by its total investment in environmental protection to avoid firm size problem. Although other factors can be applied, for example firm's total consumed energy for production, or the total investment. However due to the lack of data and confining the remarks to the relative environmental investments, the suggested constructed variables are shown as follows.

$$4.2 \quad \omega_{ij} = \frac{airt_j}{TEI_j}$$

$$4.3 \quad \eta_{is} = \frac{airp_s}{TEI_s}$$

Where:

airt: Investments in pollution treatment for air

airp: Investments in pollution prevention for air

TEI: Total Environmental Investment

i denotes number of firms and j and s denote time

Since I consider the financial variable as a proportional value to the firm's capital, these variables should be also divided to the total amount of environmental investment, otherwise it may lead us to have firm size problem seriously.

4.2.3. Applied Environmental Variables

Norwegian emissions to air of hazardous substances have been reduced considerably since 1995, in line with national targets and international obligations. The decline since 1995 is mainly due to reduced emissions in the manufacturing industries, which have been caused by improved treatment systems and manufacturing processes as well as lower activity in some industries²³. Focusing more on the observation sample, three pollutant candidates can be considered as the most bothering one in manufacturing industrial in Norway, namely CO₂, SO₂, and NO_x. The present thesis has considered these three pollutants, which according to the SFT dataset are the most common pollutants among the selected manufacturing industrial sections in Norway.²⁴

This thesis has followed a similar applied approach by Hart and Ahuja (1996) for construction of environmental variables. The object is to trace the annually changes in amount of emission of toxic materials for each firm. The index of emission of various pollutants can be constructed as follows.²⁵ Again to avoid the firm size problem, the suggested normalizing factor is production. Among several options for reducing generation of pollutants, reducing activity level (production) is the first one to be counted. As a result, I assume production and emission have a positive/direct relationship. In other words, more production results more pollution in case of lack of environmental protection in the industry. Therefore, the emission of each pollutant is normalized by production to

²³ Statistic Norway http://www.ssb.no/english/subjects/01/04/10/milgiftn_en/ Accessed: 20 Jan,2008.

²⁴ Since the dataset is too extensive, it is not included in the thesis as an appendix. However, it is available upon request.

²⁵ Jaggi and Freedman 1992; Wagner et al. 2002 have applied the index of emissions of various pollutants.

capture somehow both the internal effect (production) and external effect (environment) of firm activities.

4.4 e_{piz} = Emissions_{piz} / Production_{iz}

Here p records emissions of pollutants i denotes the firm and z is the time index. e_{piz} is also known as pollution intensity which expresses the relative relationship of emitted emission with production. There is no doubt better candidates can be applied for measuring the environmental performance of a firm. Yet this thesis has come up with one of the suggested measures, which is compatible with the available data.

Before presenting applied regression model, I would like to explain different time subscripts (t, j, s , and z) for variables. As I discussed in theoretical chapter, giving different time subscripts (t, j, s, z) to profit index, investments in pollution treatment for air, investments in pollution prevention for air, and emissions index is an explanation of different time-lagging relationship between the variables. Apparently ($t > j, s, z$) since the financial effect of investment in pollution reduction comes at the last stage. Moreover, I argue that it can be a time-difference effect between two kinds of investments. The relationship between j and s (the time subscript of two investments) can be shown as follows: $j \geq s$. It means that the treatment technology investment may affect financial performance sooner than prevention technology investment or at the same year, while this relationship cannot be reversed. In other words, the prevention technology investment is the most lagged variable in this investigation due to its time-consuming features. Emission reduction can occur at the same year of investment in treatment technology or later. Obviously, emission reduction time-index should not exceed profit index time subscript. ($z < t$) As I mentioned earlier one of the best solution to find out the relationship between the mentioned different time subscripts is to look at the correlation table between them. Due to the lack of data, the presented correlation table in chapter 5 (Table 3) cannot be considered very significant. However, it is an attempt to show the table and discuss about its components and the more detail look has left for the future work.

4.2.4. Applied Regression Model

For the regression of this thesis, a very simple model has been applied, under the OLS assumptions:

$$(1) \quad Y_{it} = \beta_{0t} + \beta_{1t}\omega_{ij} + \beta_{2t}\eta_{is} + \beta_{3t}e_{1iz} + \beta_{4t}e_{2iz} + \beta_{5t}e_{3iz} + u_{it}$$

Where:

Y_{it} refers to profit index (profit over capital)

ω_{ij} refers to air protection investment in treatment technology at time j.

η_{is} refers to air protection investment in prevention technology at time s.

e_{1iz} refers to change in CO₂ for firm i at time z.

e_{2iz} refers to change in SO₂ for firm i at time z.

e_{3iz} refers to change in NO_x for firm i at time z.

u_{it} refers to error term

i refers to the number of firms

The concerned hypothesis of this thesis is:

$$\begin{cases} H_0: \text{ if } \hat{\beta}_1 < \hat{\beta}_2 \\ H_1: \text{ if } \hat{\beta}_1 \geq \hat{\beta}_2 \end{cases}$$

In other words, a firm with more intensive investment in pollution prevention technology benefits significantly more financially or not. I consider the restricted inequality to investigate the superiority of investment in pollution prevention technology. The results of some correlations and regressions will be discussed in the next chapter.

Chapter 5: Empirical Results

In this chapter, I start by presenting descriptive statistic data and some correlations to show the approach toward picking up the related lagged variables. In the second part, I apply simple econometric model and discuss its results.

5.1. Descriptive Statistics and Correlations

Table 1 provides summary statistics for the variables. With a short glance at the description, we can see the number of firms that have invested in treatment technology is considerably more than those which have invested in prevention technology (1471>348). As I have calculated, 33 percent of investment in treatment and 26 percent of investment in prevention has been amounted to the air/climate protection.

Table 1 Summery Statistics

Variables	Obs	Mean	Std.dev	Min	Max
Profit index	3872	0.55059	4.7913	-120.2679	161.02639
Total IPT	1471	3204	14752	0	204174
Total IPP	348	6842	36150	0	300000
<i>airt</i>	1170	1367	8268	0	120000
<i>airp</i>	196	3080	1105	0	118700
ω	1169	0.3823	0.4145	0	1.000
η	196	0.6362	0.8857	0	7.5788
e_1	3391	0.01319	0.0786	0	1.312
e_2	3383	0.0000217	0.000164	0	0.00281
e_3	3391	0.0000177	0.0001254	0	0.00263
$\varphi_{it} = \sum_{k=1}^3 e_k$	3395	0.01321	0.07874	0	1.315

Table 2 reports the correlation between profit, total treatment investment in air (*airt*), and total prevention investment (*airp*).

Table 2 Pearson Correlation Coefficient

	Profit Index	<i>airt</i>	<i>Airp</i>
Profit Index	1.0000		
Prob > r under H0: $\rho=0$			
No. of Observations	3872		
<i>airt</i>	-0.00907	1.0000	
Prob > r under H0: $\rho=0$	0.7629		
No. of Observations	1108	1170	
<i>airp</i>	-0.05185	0.15657	1.0000
Prob > r under H0: $\rho=0$	0.4833	0.1601	
No. of Observations	185	82	196

As the result reveals, we can see a negative correlation between both types of investments and profit index. However, considering the related P-value's at the level of 0.05 significance, the correlation coefficients are not significant. ($0.48 > 0.05$ and $0.76 > 0.05$) In other words, according to the present data, we cannot interpret the correlations since they are not statistically significant.

I recall here that *airt* and *airp* are not the applied variables in the regression, since they are not normalized by the total amount of environmental investment. Table 3 presents correlation between the applied variables in addition to the investments- lagged variables. As I discussed earlier the purpose of generating this table is to find out the related years when the variables have the highest correlation. For example, constructed variable for pollution treatment investment with one lag ($\omega_{.1}$) has the highest correlation with profit index in compare to $\omega_{.2}$ or ω and so on.

Table 3 Correlation Coefficient for lagged variables

	Profit index	ω	ω_{-1}	ω_{-2}	η	η_{-1}	η_{-2}
Profit Index Prob > r under H0: $\rho=0$ No. of Obs.	1.0000 3872						
ω Prob > r under H0: $\rho=0$ No. of Obs	-0.01619 0.5904 1170	1.0000 1169					
ω_{-1} Prob > r under H0: $\rho=0$ No. of Obs	0.14382 0.0055 371	0.40380 <.0001 127	1.0000 396				
ω_{-2} Prob > r under H0: $\rho=0$ No. of Obs	-0.01675 0.3482 3140	0.00576 0.9742 34	0.30019 0.0477 44	1.0000 178			
η Prob > r under H0: $\rho=0$ No. of Obs	0.01319 0.8585 185	-0.18056 0.1045 82	-0.02683 0.8779 47	-0.41032 0.2100 11	1.0000 196		
η_{-1} Prob > r under H0: $\rho=0$ No. of Obs	-0.09417 0.2903 128	0.25830 0.1076 40	-0.17681 0.1843 47	-0.04090 0.8805 16	0.41449 0.0097 38	1.0000 137	
η_{-2} Prob > r under H0: $\rho=0$ No. of Obs	-0.1670 0.1266 85	0.32459 0.2379 15	0.15562 0.4783 23	-0.16698 0.3096 39	0.43692 0.3270 7	0.38806 0.2678 10	1.0000 93

According to the table, η_{-2} has the highest correlation with profit index and negative. One may expect that the highest positive correlation should be considered, but considering the P-value's, indicates that none of the correlation are significant. Hence, I follow the mentioned earlier argument and choose one-year lag for investment in treatment technology and two-year lag for investment in prevention technology and no lag for emissions respectively.

The first OLS regression on equation (1) includes following variables. Y_{it} (profit index), $\omega_{i\ t-1}$ (air protection investment in treatment technology with one-year lag), $\eta_{i\ t-2}$ (air protection investment in prevention technology with two-year lag), e_{1it} (change in CO₂), e_{2it} (change in SO₂), and e_{3it} (change in NO_x).

In the regression calculation on equation (1), SAS software program²⁶ revealed a trace of multicollinearity between the emission-related variables. (e 's) There were high standard deviations for each emission- related variable in addition to an insignificant value for both t-ratio of coefficients and the F-test. In order to detect the existence of multicollinearity, I have calculated Pearson correlation coefficient for emissions. (See Table 3)

As we can see in Table 3, there is relatively high positive correlation between the emission variables. The small P- value's indicate there is a strong evident against null hypothesis ($H_0: \rho=0$) at any level, where ρ is the correlation coefficient. Since the calculated P-value's are less than 0.05 level of significant, it indicates that there is a positive relationship between the variables. Avoiding the problem, I have merged three emission datasets (pooling data) after multiplying constructed variable corresponding CO₂ emission variable in 1000. The released amount for CO₂ in SFT dataset was 1000 tons, while the others were ton.

²⁶ Because of the sensitivity of data provided by SSB, I was not allowed to work with them out of SSB's database. SAS is one of the common applied soft ware programs for regression in SSB.

The new applied variable is $\phi_{it} = \sum_{k=1}^3 e_{kit}$ stands for Total Emission, which its description is given in the last row of Table 1.

Table 3 Pearson Correlation Coefficient for emissions

	e_1 (CO ₂)	e_2 (SO ₂)	e_3 (NO _x)
e_1 (CO ₂)	1.0000		
Prob > r under H ₀ : $\rho=0$			
No. of Observations	3391		
e_2 (SO ₂)	0.36801	1.0000	
Prob > r under H ₀ : $\rho=0$	<.0001		
No. of Observations	3380	1170	
e_3 (NO _x)	0.74400	0.49843	1.0000
Prob > r under H ₀ : $\rho=0$	<.0001	<.0001	
No. of Observations	3387	82	196

5.2. Simple Econometrics Approach

There is a slightly change in equation (1) and the equation will be presented as follows.

$$(2) \quad Y_{it} = \beta_{0t} + \beta_{1t}\omega_{ij} + \beta_{2t}\eta_{is} + \beta_{3t}\phi_{iz} + u_{it}$$

The OLS regression on equation (2) includes the same variable as before, just omitting the emission variables and including the total emission variable. At the first attempt, the years (2002-2005) were also included as the dummy variables. Due to the reduction in degree of freedom, I remove the dummy variables. However, including them could explain the ratio of change in profit index in terms of years. For instance if year 2005 was

excluded in years dummies, the coefficient of dummy variable 2004 could explain the change in profit index in 2004 compared to 2005. I hope that in the future works this matter will be considered.

From ANOVA (Analysis of Variance) result in the next page, we can see the small value of the P-value for F-test indicates that there is a strong evident against the null hypothesis which is none of the explanatory variables has any effect on dependent variable. ($0.05 > 0.01$) Hence, according to the result, the estimation of model is significant. Adjusted R-squared is the proportion of variability accounted for by the independent variable. (0.32) Table 4 provides the regression result in which there is surprisingly negative coefficient for the prevention investment ($\beta_2 = -0.69906$), indicating a negative effect from prevention investment on profit index. On the other hand, the coefficient of treatment investment indicates a positive effect on profit index. ($\beta_1 = 1.0271$) Clearly, both of the estimations (β_1 and β_2) are statistically significant at the significant level of 0.05. As we can see, the finding does not support the concerned hypothesis at any level. ($\hat{\beta}_2 > \hat{\beta}_1$)

We should notice here there is remarkable change in both estimations compared to the simple correlation coefficient reported in Table 3. The estimated effect for treatment investment has an increase (1.027 compared to 0.1438) and the estimated effect for prevention investment has a decrease (-0.69906 compared to -0.167). These variations may indicate that each of the investments is correlated with other factors that normally characterize the firms investment strategies. If the intercept coefficient was significant, we could interpret that the other influential factors reflect their effect in the intercept. With a P-value equal to 0.49, this estimator is far from being significant. The coefficient of emission variable is positive (0.61065), but considering its P-value one cannot count it as a significant estimation.

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F	Root MSE	Dependent Mean	Coeff Var	R-Square	Adj R-Sq
Model	3	10.36850	3.45617	4.44	0.0159	0.88249	0.01403		0.4120	
Error	19	14.79691	0.77878							
Corrected Total	22	25.16541				6288.21800			0.3192	

Table 4 Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > t
Intercept	1	0.20536	0.29771	0.69	0.4987
$\eta_{i\ t-2}$	1	-0.69906	0.21118	-3.31	0.0037
ω_{t-1}	1	1.02718	0.51361	2.00	0.0600
φ_{it}	1	0.61065	1.38787	0.44	0.6649

Chapter 6: Conclusion

In general, the finding supports significant estimations for both kinds of investments. Although the coefficient of prevention investment reveals a negative estimation in one hand, the coefficient of treatment investment shows a high and positive relationship with profit index. As we can see from Table 3, the correlation coefficient of prevention investment is positive at the same year with profit index which is not very plausible. Yet, I have calculated the regression with no lag for the prevention coefficient which was not significant (insignificance regarding F-test, t-ratio of coefficients) It may indicate that the negative effect of prevention investment takes longer time than applied in the present regression. In other words, desired innovation offset due to prevention investment that can exceed the compliance cost requires longer period than three years at least. It is not very far from expectation due to the character of this type of investment. On the other hand, the effect of treatment investment can be seen with one-year lag. Therefore, there is more motivation to invest in treatment technologies for firms compared to prevention technologies. It seems that investment in prevention technology due to its time-consuming and required massive financial resources is not a persuading task to be fulfilled by all firms.

Overall, the lack of richness of the data has not allowed me to assess the empirical validity of the concerned Hypothesis very significantly. The concern of this thesis was to present the approach. Here, there are some suggestions for the future empirical works with access to the data with longer period and more facilities:

- In this thesis, five sectors in industry were included. Having more sectors can improve the results.
- Controlling the sample for each sector can release the proportion of each type of investments in sectors. For example, it may be seen that prevention investment is more focused in gas and oil sector compared to chemical activities.

- In estimation of profit index, the net profit acquired from different types of investment can provide results that are more valid. As I discussed earlier, increasing in profit may occur due to different sources. The desired index should reflect just the increase in profit caused by different kinds of environmental investments.

As the presented work is the first step in investigating the effect of different environmental protection investments on financial performance in Norwegian industrial sections, there is a significant potential of improvement and research works in future. Finding a significant positive relationship between the treatment investment and profit index is a promising point that the future works with more efficient data can achieve results that are more valid.

According to the result, the answer to the title question *Prevention or Treatment Environmental Innovation, 'Which one Pays to be Green?'* is a positive support for treatment environmental technology. Similar to the previous results in this field, still the answer to the important question of *when* and *for whom* each investment should be applied is ambiguous.

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Appendix A: Questionnaires



Statistisk sentralbyrå
Statistics Norway

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Undergitt
taushetsplikt
Oppgaveplikt

Undersøkelsen om miljøvernutgifter

Industristatistikk 2002

Viktig: Blanketten skal leses maskinelt, så det er derfor viktig at utfyllingen blir utført nøyaktig. Fyll ut skjemaet fortløpende etter nummerringen på spørsmålene. **Bruk blå eller svart penn.**

Sett kryss slik: ☒ og ikke slik: ☐ Hvis kryss i feil rute: ☐ Skriv tall slik:

1	2	3	4	5	6	7	8	9	0
---	---	---	---	---	---	---	---	---	---

Del 1. Driftsutgifter

Hva skal med?

- Lønnskostnader til ansatte som arbeider med miljøspørsmål, rapportering og utslippstillatelser
- Utgifter til eksterne konsulenter, kjøp av andre tjenester
- Utgifter til utslippstillatelser, avfallsgebyr og avløpsgebyr mv.
- Kjøp av varer, kontorkostnader mv. som inngår i produksjon av miljøverntiltak
- Drift, reparasjon og vedlikehold av miljøvernutstyr, utgifter til operasjonell leasing av miljøvernutstyr

Hva skal ikke med?

- Generelle miljøskatter, f.eks. CO₂-avgifter (SSB får denne informasjonen via andre kanaler og trenger ikke direkte rapportering fra bedrifter)
- Avskrivninger (utgifter relatert til kapitalslitasje)
- Renter på lån
- Bot for brudd på utslippstillatelser eller andre miljørelaterte bøter eller kompensasjon o.l. til tredje part for skader knyttet til miljøskadelig utslipp

1 Hadde bedriften driftsutgifter knyttet til **avløp og produksjonsvann** i 2002?

For eksempel: avløpsgebyrer, drift og vedlikehold av oppsamlingsstanker, forbehandling av avløp eller produksjonsvann, overvåkings- og analyseutgifter, bruk av filtermedia, utgifter relatert til utslippstillatelser.

☐ Ja →

1 000 kr. eks. MVA

☐ Nei
☐ Vet ikke
 Gå til **2**

Hvor stor andel av dette var kjøp fra andre aktører (inkl. gebyrer)? Gi et estimat. →

Prosent

2 Hadde bedriften driftsutgifter knyttet til **avfall** i 2002?

For eksempel: avfallsgebyrer, forbehandling og transport av avfall, sortering, dehydrering, avgifting, avvanning, sammenpressing osv., utgifter relatert til utslippstillatelser for spesialavfall, overvåkings- og analyseutgifter.

☐ Ja →

1 000 kr. eks. MVA

☐ Nei
☐ Vet ikke
 Gå til **3**

Hvor stor andel av dette var kjøp fra andre aktører (inkl. gebyrer)? Gi et estimat. →

Prosent

3 Hadde bedriften driftsutgifter knyttet til **luft og klima** i 2002?

For eksempel: utgifter knyttet til bruk av filtermedia eller andre metoder for reduksjon av utslipp, overvåkings- og analyseutgifter og utgifter relatert til utslippstillatelser.

☐ Ja →

1 000 kr. eks. MVA

☐ Nei
☐ Vet ikke
 Gå til **4**

Hvor stor andel av dette var kjøp fra andre aktører (inkl. gebyrer)? Gi et estimat. →

Prosent

4 Hadde bedriften driftsutgifter knyttet til **jord og grunnvann** i 2002?

For eksempel: driftsutgifter knyttet til å forebygge forurensning til jord og grunnvann, utgifter til bruk av måleutstyr og utgifter for kontroll, behandling og fjerning av forurensning i jord og grunnvann.

☐ Ja →

1 000 kr. eks. MVA

☐ Nei
☐ Vet ikke
 Gå til **5**

Hvor stor andel av dette var kjøp fra andre aktører (inkl. gebyrer)? Gi et estimat. →

Prosent

RA-0514b

04.2003

Skjema foreligger på begge målformer

Vend!

5 Hadde bedriften driftsutgifter knyttet til **biologisk mangfold og landskap** i 2002?

For eksempel: vedlikehold av områder som beskytter eller rehabiliterer fauna, flora eller naturlandskap, vedlikehold av utvendig og allment tilgjengelig parkanlegg.

- ☐ Ja →
☐ Nei
☐ Vet ikke

Gå til **6**

1 000 kr. eks. MVA

Hvor stor andel av dette var kjøp fra andre aktører (inkl. gebyrer)? Gi et estimat.

Prosent

⌊

6 Hadde bedriften driftsutgifter knyttet til **andre miljøvernformål** i 2002?

For eksempel: utgifter rettet mot å redusere støy, vibrasjoner eller stråling. Utgifter til forskning og utvikling. Generelle driftsutgifter knyttet til arbeid med miljørapportering, miljøstyringssystemer, årsmeldinger om miljøresultater og miljøvernrelatert opplæring av ansatte (men ikke intern HMS). Andre utgifter som ikke kan fordeles etter miljøområde tas også med her.

- ☐ Ja →
☐ Nei
☐ Vet ikke

Gå til **Del 2. Investeringer**

1 000 kr. eks. MVA

Hvor stor andel av dette var kjøp fra andre aktører (inkl. gebyrer)? Gi et estimat.

Prosent

Del 2. Investeringer

Spørsmålene om investeringsutgifter er delt i to ut fra type investering: spørsmålene 7 til 13 omhandler prosesseksterne investeringer, mens spørsmålene 14 til 24 omhandler prosessinterne investeringer. Skillet mellom prosesseksterne og prosessinterne investeringer er vanskelig. Les forklaringen nedenfor nøye før du begynner å fylle inn svarene, slik at du unngår å måtte korrigere utfyllingen.

Prosesseksterne investeringer: Investeringer i utstyr og anlegg for å samle opp, måle eller fjerne forurensning etter at den er oppstått i produksjonsprosessen, samt behandle og deponere avfallsstoffer. Dette er utstyr og anlegg som er uavhengig av produksjonsprosessen. Slikt utstyr betegnes også som "end-of-pipe-utstyr."

Prosessinterne investeringer: Investeringer knyttet til renere teknologi i selve produksjonsprosessen, dvs. utstyr eller anlegg som skal forhindre at forurensning oppstår eller som reduserer omfanget av den. Slikt utstyr og slike anlegg betegnes også som integrert teknologi, renere teknologi eller "pollution prevention". Utgiftene til miljøverninvesteringer vil her kunne være deler av de totale utgiftene til nytt utstyr eller anlegg. Dette kan gjøre det vanskelig å anslå selve miljøvernutgiften. Se veiledning før spørsmål 14 for utdypende forklaring.

2a. Prosesseksterne investeringer

7 Har bedriften gjort investeringer i prosesseksterne anlegg eller utstyr i 2002?

- ☐ Ja → Gå til **8**
☐ Nei
☐ Vet ikke

Gå til del 2b om prosessinterne investeringer

⌊

8 Har bedriften gjort investeringer i prosesseksternt utstyr eller anlegg rettet mot **avløp eller produksjonsvann** i 2002?

For eksempel: tiltak som begrenser utslipp, oppsamlingsbasseng for lekkasjer, eget renseanlegg, rørledninger til renseanlegg og avløpsnett, kjølesystemer for produksjonsvann, nøytraliseringstanker, sedimenteringstanker, utstyr for behandling av avløpslam, overvåkningsutstyr.

- ☐ Ja →
☐ Nei
☐ Vet ikke

Gå til **9**

1 000 kr. eks. MVA

9 Har bedriften gjort investeringer i prosesseksternt utstyr eller anlegg rettet mot **avfall** i 2002?

For eksempel: containere, sorteringsutstyr, godkjente forbrenningsovn, egne deponier, avfallspresse, slamtørkeseng, utstyr for hygienisering eller forbehandling, biler for transport av avfall.

- ☐ Ja →
☐ Nei
☐ Vet ikke

Gå til **10**

1 000 kr. eks. MVA

10 Har bedriften gjort investeringer i prosesseksternt utstyr eller anlegg rettet mot **luft og klima** i 2002?

For eksempel: filter, sykkloner, kjølesystemer, katalysatorer for behandling av prosessgasser, renseutstyr med posefilter eller elektrofilter, andre tiltak for begrenset utslipp av støv og partikler, tiltak som begrenser utslipp, overvåkningsutstyr.

- ☐ Ja →
☐ Nei
☐ Vet ikke

Gå til **11**

1 000 kr. eks. MVA

⌊

11 Har bedriften gjort investeringer i prosesseksternt utstyr eller anlegg rettet mot **jord og grunnvann** i 2002?

For eksempel: utstyr for rensing av forurenset jord, tiltak for å forebygge forurensning av jord og grunnvann, beskyttelse mot erosjon, samt forsøltning, utstyr for å redusere bruk av grunnvann i produksjonsprosessen.

☐ Ja → 1 000 kr. eks. MVA

☐ Nei

☐ Vet ikke

Gå til **12**

12 Har bedriften gjort prosesseksterne investeringer rettet mot bevaring av **biologisk mangfold og landskap** i 2002?

For eksempel: skogplanting med formål å bevare arter, beplantning av trær og busker for å lage naturlige korridorer for fauna eller skjule bygninger og andre tekniske inngrep, opparbeiding av parker tilgjengelige for allmennheten, bevaring av områder pga. biologisk mangfold, rehabilitering av landskap.

☐ Ja → 1 000 kr. eks. MVA

☐ Nei

☐ Vet ikke

Gå til **13**

13 Har bedriften gjort investeringer i prosesseksternt utstyr eller anlegg rettet mot **andre miljøvernformål** i 2002?

For eksempel: lydfeller, støvvegger, innbygging av støykilder, utstyr for å redusere vibrasjoner, kjøp av datasystemer for miljøstyringssystemer og miljørapportering.

☐ Ja → 1 000 kr. eks. MVA

☐ Nei

☐ Vet ikke

Gå til delen om prosessinterne investeringer

2b. Prosessinterne investeringer

I denne delen skal du oppgi alle investeringer knyttet til renere teknologi i selve produksjonsprosessen, dvs. utstyr eller anlegg som skal forhindre at forurensning oppstår eller som reduserer omfanget av den. For den enkelte investering skal det oppgis en prosentandel knyttet til miljøvern (miljøvernutfikten).

For investeringsutgifter der formålet med investeringen i sin helhet har vært redusert utslipp/bedre miljø regnes hele investeringsutgiften som en miljøvernutfikt.

For investeringer der hensikten delsvis har vært miljøhensyn og dels å få en mer effektiv produksjonsprosess et., er det bare utgiftsdelen som er knyttet til miljøvern som regnes som miljøvernutfikt. Dette kan det være vanskelig å identifisere. I slike tilfeller kan følgende framgangsmåte brukes:

1. Dersom det finnes rimeligere alternativer til den investeringen som er gjort, men som ikke ville gi de oppnådde miljøeffekter, regnes differansen mellom den faktiske utgiften og det rimeligere alternativet som miljøvernutfikt.
2. Dersom det er mulig å anslå en merkostnad som skyldes miljøvernensyn, kan denne merkostnaden regnes som miljøvernutfikt.
3. Dersom det ikke er mulig å gi et anslag på miljøverndelen av investeringen, gi likevel en beskrivelse av investeringen, men sett 0 i prosentfeltet i stedet.

Utgifter til nytt utstyr og maskiner som har bedre miljøegenskaper enn de som skiftes ut, regnes ikke som miljøvernutfikter dersom disse bedrede egenskapene har blitt standard teknologi.

Eksempler på prosessinterne investeringer:

Avløp og produksjonsvann:

Resirkuleringssystemer, lukkede kjølesystemer, vakuumpumper, utstyr for gjenbruk av eller for å redusere bruken av vann i produksjonsprosessen.

Avfall:

Investeringer i utstyr/prosesser som gir mindre avfall, mindre skadelige avfallstyper eller mer effektiv bruk av råstoffer, f.eks. ved at de muliggjør endringer i innsatsvarer.

Luft og klima:

Tanker med flytende tak (sammenliknet med f. eks. tanker uten tak), systemer for damputveksling og resirkulering av prosessgasser, kontrollsystemer for optimal forbrenning/drift, endringer som er nødvendig for bruk av mindre miljøskadelige kjølemedia, endringer i produksjonsystemer som betyr at mindre miljøskadelige produkter kan brukes i produksjonsprosessen.

Jord og grunnvann:

Dobbeltveggede tanker (sammenliknet med enkeltveggede tanker) installert for vern av jord og grunnvann. Utskrifning av kabler som inneholder PCB.

Biologisk mangfold og landskap:

Ekstrakostnader for bevaring av verdifullt landskap eller vernaede områder ved utbygging av infrastruktur som f.eks. avløpsnett, el-nett, veier.

Andre miljøvernformål:

Fundamentering som demper vibrasjoner og lavstøybrenner, lavstøytstyr og -motorer. Tiltak for å redusere magnetfelt.

14 Har bedriften gjort investeringer i integrert eller renere teknologi i 2002?

☐ Ja → Gå til introduksjonen for spørsmål **15**

☐ Nei

☐ Vet ikke

Gå til **25**

Kan du gi en kort beskrivelse av investeringen? Oppgi både totalbeløpet for investeringen og et estimat i prosent for den delen av investeringen som er tilknyttet miljøvern. Hvis bedriften har gjort flere små investeringer rettet mot det samme miljøformålet, kan disse slås sammen ved utfyllingen av tabellen.

Hvis du trenger flere linjer, ta kopi av denne siden, fyll den ut og send den som vedlegg!

Beskrivelse av de prosessinterne investeringene	Total investeringsutgift (1000 kr, eks. MVA)	Prosent tilknyttet miljøvern	Hovedmiljøformål (sett bare ett kryss)					
			Avløp/ vann	Avfall	Luft/ klima	Jord/ grunn- vann	Biologisk mangfold/ landskap	Annet
15			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
16			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
17			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
18			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
19			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
21			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
22			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
23			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
24			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

25 Oppgi hvor mange minutter det tok å fylle ut skjemaet, inkludert datainnhenting og skjemautfylling minutter

26 Kryss av for å motta e-postmelding når SSB publiserer resultatene fra denne undersøkelsen ☐

Merknader:

Hvem kan vi kontakte hos dere?

Navn: Tlf.: e-post:

Sted/dato: Underskrift:

Hvis dere har noen spørsmål, ta gjerne kontakt med oss:

Angående utfylling av skjema: Julie Hass, Seksjon for miljøstatistikk, tlf. 21 09 45 15, e-post: julie.hass@ssb.no

Angående utsettelse av innsending: Guro Henriksen, tlf 21 09 47 65, e-post: guro.henriksen@ssb.no